DIFFRACTION : RECENT RESULTS AND IMPLICATIONS FOR LHC

L. SCHOEFFEL
CEA Saclay, DAPNIA-SPP,
91191 Gif-sur-Yvette Cedex, France

With the knowledge of diffractive parton densities extracted from HERA data, we discuss the observation of exclusive events using the dijet mass fraction as measured by the CDF collaboration at the Tevatron. In particular the impact of the gluon density uncertainty is analysed. Some prospects are given for diffractive physics at the LHC.

1 Diffraction at HERA

Since years, the Pomeron remains a subject of many interrogations. Indeed, defined as the virtual colourless carrier of strong interactions, the nature of the Pomeron is still a real challenge. While in the perturbative regime of QCD it can be defined as a compound system of two gluons in the approximation of resumming the leading logs in energy, its non-perturbative structure is basically unknown. In the recent years, an interesting experimental investigation on "hard" diffractive processes led to a new insight into those problems. At the HERA accelerator, it has been discovered that a non negligeable amount of γ^*–proton deep inelastic events can be produced with no visible breaking of the incident proton. There are various phenomenological interpretations of this phenomenon, but a very appealing one relies upon a partonic interpretation of the structure of the Pomeron [1] . In fact, it is possible to nicely describe the diffractive cross-section data from HERA by perturbative QCD evolution equations of parton distributions in the Pomeron combined with flux factors describing phenomenologically the probability of finding a Pomeron state in the proton [2]. Sets of quark and gluon distributions in the Pomeron following these equations are obtained. The gluons dominate the diffractive exchange and carry approximately 70 % of the momentum. The diffractive gluon density is presented in figure 1. At high β, where β denotes the fraction of the particular parton in the pomeron, this density is not well constrained from the QCD fits. To quantify this uncertainty, we multiply the gluon distribution by the factor $(1-\beta)^\nu$ as shown in figure 1 : we obtain the uncertainty on the parameter ν, $\delta(\nu) = 0.5$, which corresponds to a large spread at large β for the gluon density.

In the following, we investigate how this uncertainty influences the results on dijet mass fraction as measured at the Tevatron.

2 Diffraction at Tevatron and LHC

A schematic view of non diffractive, inclusive double pomeron exchange and exclusive diffractive events at the Tevatron or the LHC is displayed in figure 2. The upper left plot shows the "standard" non diffractive events where the Higgs boson, the dijet or diphotons are produced directly by a coupling to the proton associated with proton remnants. The bottom plot displays

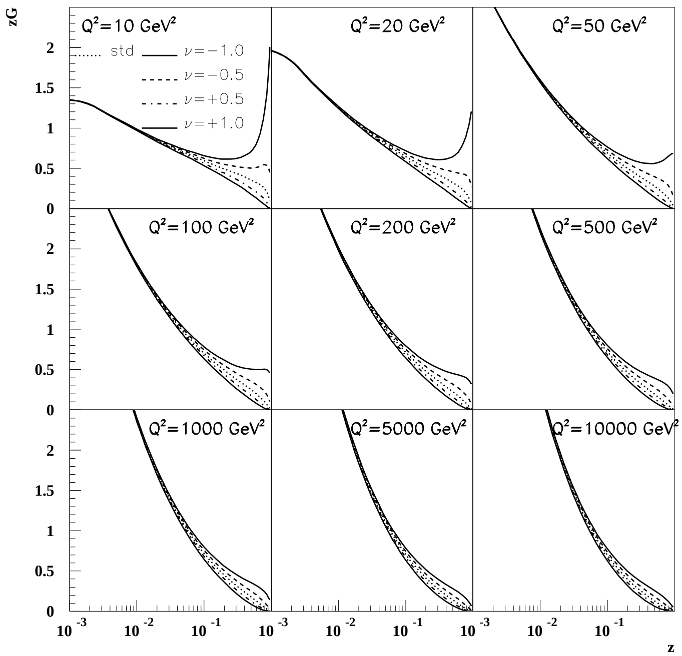

Figure 1: Uncertainty of the gluon density at high β (here $\beta \equiv z$). The gluon density is multiplied by the factor $(1-\beta)^{\nu}$ where ν=-1., -0.5, 0.5, 1. The default value is $\nu = 0$.

the standard diffractive double Pomeron exchange (DPE) where the protons remain intact after interaction and the total available energy is used to produce the heavy object and the pomeron remnants. These events can be described using the diffractive gluon density measured at HERA and shown in figure 1. There may be a third class of processes displayed in the upper right figure, namely the exclusive diffractive production. Exclusive events allow a precise reconstruction of the mass and kinematical properties of the central object using the central detector or even more precisely using very forward detectors installed far downstream from the interaction point. The mass of the produced object can be computed using roman pot detectors and tagged protons, $M = \sqrt{s\xi_1\xi_2}$, where $\sqrt{s}$ is the energy of the reaction in the center of mass frame and $\xi_{1,2}$ represent the fractions of energy lost by both protons. We see immediately the advantage of those processes : we can benefit from the good roman pot resolution on $\xi_{1,2}$ to get a good resolution on mass. Therefore, it is possible to measure the mass and the kinematical properties of the produced object and use this information to increase the signal over background ratio by reducing the mass window of measurement [3].

If such exclusive processes exist in DPE, the most appealing is certainly the Higgs boson production through this channel at the LHC [3]. It cannot be observed at the Tevatron due to the low production cross section, but one can use present measurements at the Tevatron to investigate any evidence for the existence of exclusive production in DPE.

3 Dijet mass fraction at the Tevatron

The CDF collaboration has measured the so-called dijet mass fraction (DMF) in dijet events when the antiproton is tagged in the roman pot detectors and when there is a rapidity gap on the proton side to ensure that the event corresponds to a double pomeron exchange [3,4]. The measured observable R_{JJ} is defined as the ratio of the mass carried by the two jets divided by the

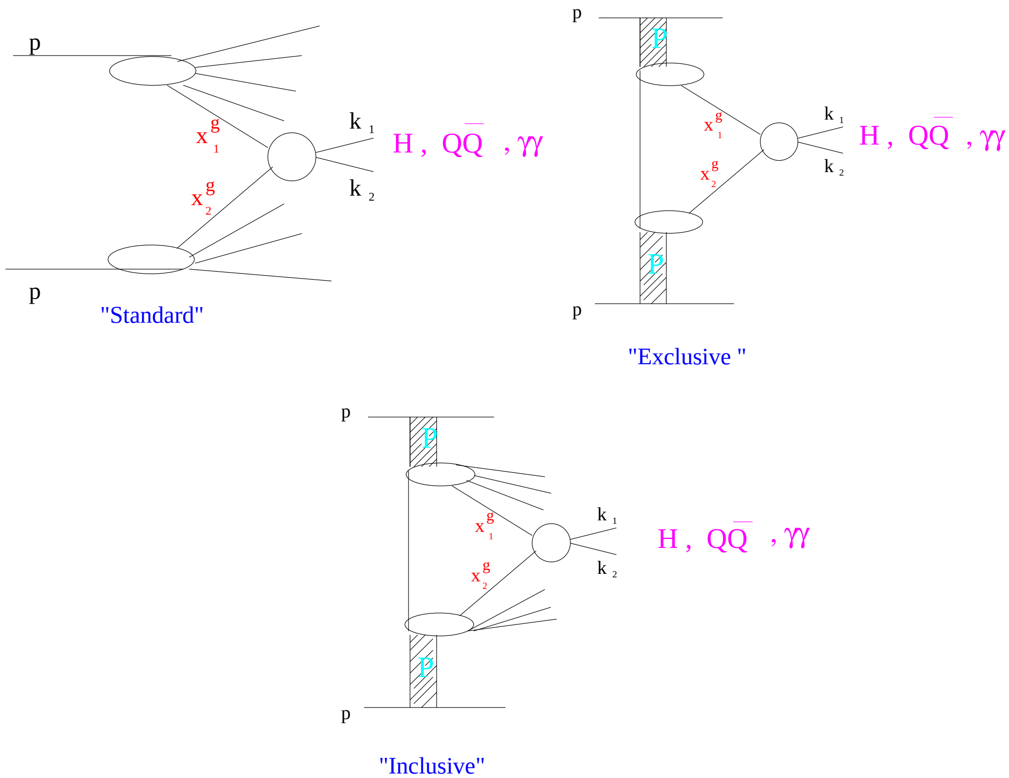

Figure 2: *Scheme of non diffractive, inclusive double pomeron exchange and exclusive events at the Tevatron or LHC*

total diffractive mass. The DMF turns out to be a very appropriate observable for identifying the exclusive production, which would manifest itself as an excess of the events towards $R_{JJ} \sim 1$. Indeed, for exclusive events, the dijet mass is essentially equal to the mass of the central system because no pomeron remnant is present. Then, for exclusive events, the DMF is 1 at generator level and can be smeared out towards lower values taking into account the detector resolutions. The advantage of DMF is that one can focus on the shape of the distribution. The observation of exclusive events does not rely on the overall normalization which might be strongly dependent on the detector simulation and acceptance of the roman pot detector. Results are shown in figure 3 with Monte-Carlo expectations calculated using DPEMC [5]. As we have seen in section 1, the uncertainty on the gluon density is large at large β, which directly reflects in different shapes for the DMF in the inclusive part [6]. This is illustrated in figure 3 (left), where we show the impact of the parameter ν, which quantifies the diffractive gluon density error, on the shape of the DMF. We observe that it is not sufficient to reproduce the behaviour of the DMF when $R_{JJ} \sim 1$. Indeed, we see a clear deficit of events towards high values of the DMF, where exclusive events are supposed to occur. In figure 3 (right), a specific model describing exclusive events [7] is added to the inclusive prediction and we obtain a good agreement between data and the sum of MC expectations [5]. It is a first evidence that exclusive events could contribute at the Tevatron.

4 Dijet mass fraction at the LHC

The search for exclusive events at the LHC can be performed in the same channels as the ones used at the Tevatron. A direct precise measurement of the gluon density in the pomeron through the measurement of the diffractive dijet cross section at the LHC will be necessary to study in detail the exclusive events in the dijet channel and measure their cross section. This is why it is important to have the roman pots and the Silicon detectors (inside roman pots) installed during

the 2009-2010 shutdown so that these measurements will allow to tune the models and the MC. On the other hand, it is also important to look for different methods to show the existence of exclusive events [3]. In addition, some other possibilities benefitting from the high luminosity of the LHC appear. One of the cleanest way to show the existence of exclusive events would be to measure the dilepton and diphoton cross section ratios as a function of the dilepton/diphoton mass. If exclusive events exist, this distribution should show a bump towards high values of the dilepton/diphoton mass since it is possible to produce exclusively diphotons but not dileptons at leading order.

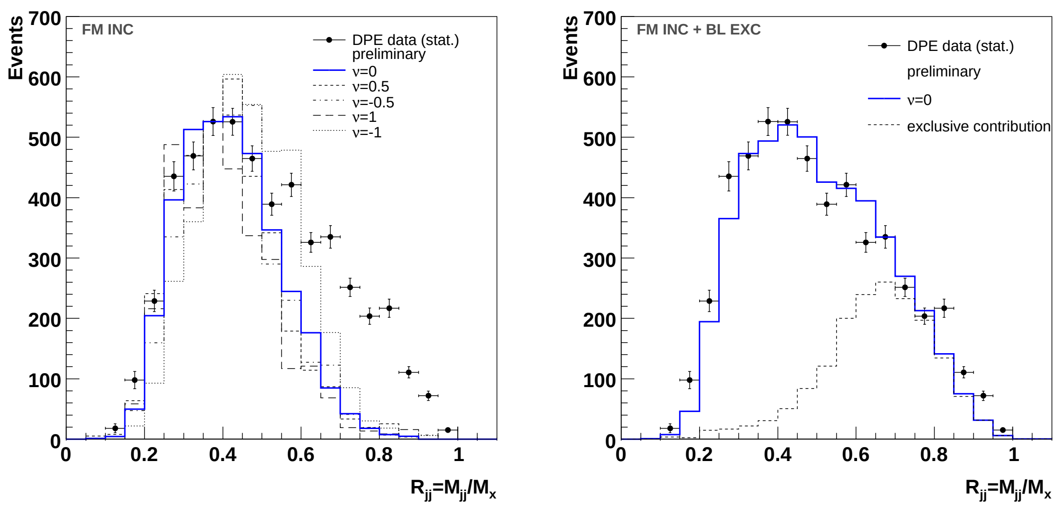

Figure 3: Dijet mass fraction for jets $p_T > 10\,\mathrm{GeV}$. The data are compared to inclusive model predictions including the uncertainty of the gluon density at high β (left) and to the sum of inclusive and exclusive predictions (right).

5 Conclusions

We have discussed a first evidence for the existence of exlusive events in double pomeron exchange at the Tevatron. If such events can be also observed at the LHC, it would be possible to produce a Higgs boson as well as of a dijet system regarding the cross section values accessible at the LHC. The great benefit of exclusive events concerns the precise reconstruction of the mass of the central object, using roman pot detectors installed far downstream from the interaction point [3]. It gives the opportunity to work with a favorable signal/background ratio compared to standard Higgs searches with a mass below 150 GeV.

References

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